Comments on the Debate over the Proposal to Redefine UTC

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Abstract

In 2015 the World Radio Conference (WRC) is scheduled to consider a proposal that would redefine Coordinated Universal Time (UTC) through the elimination of leap seconds after a specified date. This paper discusses the benefits and drawbacks of the proposition. In general, terrestrial systems would be simplified and rendered more reliable in the absence of leap seconds, while systems that utilize the current near-equality between UT1 and UTC would require some adjustments.. The systems that would benefit the most from a redefinition are related to commerce and navigation.

1. Introduction

UTC, the time standard for commerce and most other human activities, has since its inception used leap seconds so as to keep |UT1-UTC| <0.9 seconds. This system was established as compromise, taking into account the needs of mariners for celestial navigation. Since then GNSS systems have replaced celestial navigation and the internet has made UT1-UTC instantly available, with world synchronization and syntonization reaching unprecedented levels. Due to these changed circumstances, a proposal to eliminate leap seconds was brought before the International Telecommunications Union (ITU) in the late 20th century, and as part of the process URSI was asked to comment.

From 1999-2002 this author chaired a working group of Commission J to study this matter, and from 2002-2005 he chaired an URSI-wide working group on the matter. The first effort made no attempt to restrict itself to URSI membership, while the second one was targeted to the URSI Commissions. Neither study identified any systems that would be certain to fail if the proposition passed, nor did they identify any strong or compelling interest either way within the URSI community. As a result, the URSI directorate discontinued the working group and decided not to reply to the ITU letter. Although many if not all surveys have revealed little interest in the leap second, the URSI outcome might have been different had the author been made aware of a resolution passed by URSI Commission A in 1999, which supported the redefinition (Appendix II). URSI notwithstanding[1], the proposition has advanced within the ITU and could be accepted at WRC-15. Whatever may be the outcome with the ITU, it is certain that a spirited debate will continue in other arenas, including the listserve http://six.pairlist.net/mailman/listinfo/leapsecs. Founded at the U. S, Naval Observatory (USNO), it has generated thousands of emails that can readily be browsed. This paper will discuss technological, cost, and philosophical issues. One difficulty with gathering information is that many affected parties do not disclose past failures or current vulnerabilities as a matter of policy – for example a business that fully informs people of all its past mishaps, of any nature, might expect a large drop in its clientele.

2. The Technological Issues

An issue raised by the proponents is that communications cannot easily adjust to leap seconds and in many cases systems fail due to human or programming error. GPS circumvents the problem through use of a navigational timescale (GPS Time) that does not incorporate new leap seconds, while UTC is provided through supplementary corrections provided in the navigation message. The dichotomy between these two timescales has led to occasional confusion and problems. Ground-based issues with GPS, in which some receivers incorrectly add while others do not incorporate, have been reported. Since an error of one second in UTC corresponds to an east-west distance of roughly 355 meters at the latitude of 40 degrees (roughly that of our host city Beijing), it is conceivable that an incorrectly programmed GPS receiver could lead to a navigational disaster. The problem is not limited to GPS, and at least one LORAN transmitter failure has been ascribed to a leap second. Leap second insertions can therefore be considered a hazard to navigation.

Leap seconds have also interfered with commerce. One reason is that some computer systems have time-checks that automatically enter into a failure-mode when a leap second insertion causes the time to apparently go backwards; the posix system for example has no built-in method for handling leap seconds. Because of such hazards, leap seconds inserted on December 31 or June 30 have resulted in disruptions, which can occur during normal business hours in the

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Asia-Pacific regions of the world. Also, some systems have been misprogrammed to insert the leap second at midnight local time, resulting in a temporary asynchronicity. On July 31, 2012, one month after a leap second insertion, several NTP servers suddenly added a new leap second, which lead to speculations of hackers exploiting or causing this.[2] It has been observed that never has an end of the month gone by without at least one Network Time Protocol (NTP) server incorrectly setting or missing to set the leap second flag[3]; although typically the largest number of failures occur after a leap second insertion, with some servers still incorrect after a day or two. These failures have the cause of web page shutdowns and reportedly resulted in the grounding of flights.

For many astronomical systems, adjustments are often not necessary because precise values of UT1-UTC are already downloaded and used in the computations. In some cases however, systems that now use UTC as an approximation for UT1 might be run directly on UT1, or be redesigned by making a slight software modification so as to insert a correction for UT1-UTC at the clock level. Doing so is conceptually simple for users with internet access, as that data are already on web pages maintained by the International Earth Rotation and Reference Systems Service (IERS). Many groups have expressed a willingness to set up NTP servers based on UT1, among them the IERS and the USNO**,** which currently manages the IERS's rapid service. There is consideration being given to expanding standard NTP so that UT1 could be obtained as a client-requested option.

An issue involving the Astronomical Almanac would be that listings of the times of very future events might require post-publication correction in subsequent almanacs if |UT1-UTC| is not adequately predicted. A few events, such as the times of eclipses and occultations, are better done without leap seconds – as UTC is currently defined they would be in error if the leap seconds are incorrectly estimated. However, the Astronomical Almanac is typically sent to the printer two years in advance, and with such a short prediction interval the granularity of the Almanac's tables makes them insensitive to the effects of UT1 unpredictability. On-line Almanacs can be instantly adjusted as the value of UT1-UTC is measured and re-predicted. Similar considerations are involved for celestial navigation – the algorithms for the tables that are currently produced for celestial navigation would have to be adjusted. The adjustment would not be difficult for the experts at the USNO and elsewhere to bring about. For celestial navigation, the accuracy of a sextant is about one arcminute, so that the tables that must be used by the few mariners who would know how to do celestial navigation would have to incorporate a prediction of UT1 that is accurate to 4 seconds; this could easily be generated a decade or more in advance.

The dollar costs of inserting leap seconds, as well as the costs of adjusting systems for the termination of leap seconds, have been estimated but in some instances are controversial. Several optical observatories have estimated small multiples of $10,000 for programmer time and equipment purchase, while certain unofficial estimates have been higher. Based upon the USNO estimate that the costs of retooling our 61" telescope, our optical interferometer, our VLBI correlator, and our Almanac computations are negligible, we suspect the cost of the corrections would be less expensive than estimated and perhaps covered naturally in the 5-year (or longer) period that would be allowed before the ITU resolution goes into effect. The largest entities involved in space navigation, NASA and the U.S. Department of Defense (DOD), have publicly come out in favor of the resolution despite the ensuing one-time setup costs for inspection and adjustment of computer code. Similarly, the European and Japanese Space Agencies (ESA and JAXA) have not objected to the redefinition.

3. Philosophical and Social Issues

A variety of non-technical concerns were noted in the several surveys. Although some were due to lack of knowledge, they could be determinants in the voting of nations whose representatives ultimately decide on the proposition. There is, for example, an incorrect general perception that the effect of a change on human behavior would be noticed in our lifetimes, or that the leap seconds destabilize atomic clocks. Given the slow rate at which UTC would diverge from solar time, the timescale by which society would have to adjust is longer than that in with which language changes, time zones change, and work habits change. As UTC-UT1 grows over centuries, more people would naturally begin arriving at work or school at later times, as judged by the clock readings; and this would ensure that there is no change in the arrival times with respect to sunrise. A translator of a book to whatever language is spoken 1,000 years from now might need to add a footnote or adjust the numerical time of day along with those describing financial currency, national borders, political parties, and social customs. A translator of a book 100 years from now would need to make no adjustments, as the < 1 minute difference would be much less than the natural variation of sunrise between winter and summer, the 1 hour switches for daylight time, and the up-to-16 minutes difference in the "equation of time" (the time of noon, or maximum solar elevation) as the Earth moves unevenly through its eccentric orbit.

No religious group has taken a stand on this issue. Just like sunrise and moonset predictions, the inequality of UT1 and UTC would simply be one more term in the equations solved by experts. As in current practice, the user would obtain time from the newspaper, internet, or smart-phone app.

An argument has recently been raised that abandoning new leap seconds requires changing the name of UTC. This argument has been almost universally endorsed by the opponents of the resolution, and as universally rejected by the resolution's proponents. Further, we are unaware of any person or group that would support the redefinition, but only if there were a name change. A committee of the International Standards Organization (ISO) has endorsed the name change without taking a stand on the proposal itself, but this is contrary to standard metrological convention. Examples are the 1925 redefinition of GMT to start each day at midnight rather than noon, and more recently retaining the name of kgm and meter when they were redefined. Also, the term "planet" was not changed when the IAU redefined it in 2006, and as a consequence downgraded Pluto. Further, it has been frequently noted the redefinition of UTC would bring it closer to what its name implies. It is still a time coordinated among laboratories, and universal in the sense of a universal reference, but it would also become universal in the sense of being in harmony with the universe, for which the time is continuous.

Finally, a very disingenuous set of objections have appeared in the British popular press. Perhaps the most dramatic one is the assertion that children will soon have to go to school in the dark – although even by 2100 the total effect of stopping leap seconds would be less than one minute, while over millennia the numerical times of school hours would be gradually shifted to compensate. In addition, easily-googled nationalistic statements and headlines include the following: "Greenwich Mean Time could drift to the United States", "Time is up for Britain", "Britain fights to be the centre of time", and "A split second could spell end of GMT". These are noted here only because, in conjunction with considerably less sensational mis-statements in web pages specifically set up in the UK to inform the public[4], they may unduly influence that government's policy.

5. Conclusion

We have described the reasons for redefining UTC and provided rebuttals for arguments that have been raised against it. Official United States policy supports the redefinition of UTC as originally proposed to the ITU, based upon public consultation of the private sector by the Federal Communications Commission (FCC) and of the government sector, by a different agency (the National Telecommunications and Information Administration, NTIA). However, the reasoning presented here is our own and not necessarily reflective of the considerations that went into the United States' governmental decision.

6. Acknowledgments

We thank Tom Van Baak for his work maintaining the leapseconds discussion group.

7. References

1. At this meeting, URSI Commission A again passed a resolution in favor of the redefinition, and the URSI Secretariat has forwarded it to the IUCAF (Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science) with a recommendation to forward it to the ITU. (This footnote was added in proof)
2. https://groups.google.com/forum/#!topic/comp.protocols.time.ntp/vhVlH4ENsJQ
3. Dr. David Malone's web page, http://www.maths.tcd.ie/~dwmalone/time/leaps/
4. http://leapseconds.co.uk. We notified the webmaster of too large estimates for the rate of divergence between UT1 and UTC, an incorrect statement about shadows not pointing south at midday, and other issues. As a result they graciously added a somewhat misnamed "American perspective" as http://leapseconds.co.uk/wp-content/uploads/A-US-perspective.pdf,

Appendix I. Added in proof

This paper was one of several on the redefinition of UTC. As a result of discussions, URSI's Commission passed the resolution below by unanimous vote. Subsequently, the URSI Secretariat passed it to the URSI representative of the Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science (IUCAF) for action.

Resolution from the Business Meeting of URSI Commission A – Beijing 2014
Opinion on the redefinition of UTC requested by ITU
22 August 2014
URSI Commission A

considering that
* in 1971, the ITU-R (formerly CCIR, International Consultative Committee for Radiocommunications) proposed the present form of UTC (Universal Time Coordinated), which is based upon the SI second but remains linked to the variable rotation of the Earth through the introduction of leap seconds in such a manner that UT1-UTC will always less than 1 second,
* this proposal was accepted after discussions with BIH (Bureau International de l'Heure), URSI, IAU, IUGG, and other bodies active in positioning and navigation, this system has worked well for most purposes, at the time of introduction, the future implementation of satellite and other systems which cannot easily incorporate the leap second was not foreseeable,
* a proposal on the redefinition of UTC is under consideration by ITU,
* the CCTF (Consultative Committee for Time and Frequency) of CIPM has endorsed the suggestion that no additional leap second should be inserted into UTC,
* the Commission A of URSI expressed its opinion in 1999 as in the appendix,fully supports
* the action to consult on this subject with the appropriate Unions, the IERS (International Earth Rotation and Reference Systems Service) and other bodies interested in the use of time scales, and is of the opinion that
* No further leap seconds should be inserted, and UTC should become a unique and continuous reference time scale and requests that
* URSI endorse and forward this opinion to ITU.

Appendix II, the Commission A resolution passed in 1999 (also added in proof)

URSI Plenary Assembly – Toronto 1999
Opinion on discontinuing the leap second inside UTC

URSI Commission A

considering that
* in 1971, the ITU-R (formerly CCIR, International Consultative Committee for Radiocommunications) proposed the present form of UTC (Universal Time Coordinated), which is based upon the SI second but remains linked to the variable rotation of the Earth through the introduction of leap seconds in such a manner that UT1-UTC will always less than 1 second,
* this proposal was accepted after discussions with BIH (Bureau Internationale de l'Heure), URSI, IAU, IUGG, and other bodies active in positioning and navigation,
* this system has worked well for most purposes,
* at the time of introduction, the future implementation of satellite and other systems which cannot easily incorporate the leap second was not foreseeable,
* the CCTF (Consultative Committee for Time and Frequency) of CIPM is discussing the suggestion that no additional leap second practice should be inserted into UTC, and it is calling the advice of the scientific Unions and other bodies concerned,

fully supports
* the action to consult on this subject with the appropriate Unions, the IERS (International Earth Rotation Service) and other bodies interested in the use of time scales,

and is of the opinion that
* No further leap seconds should be inserted, if no major objections will arise from that consultation.